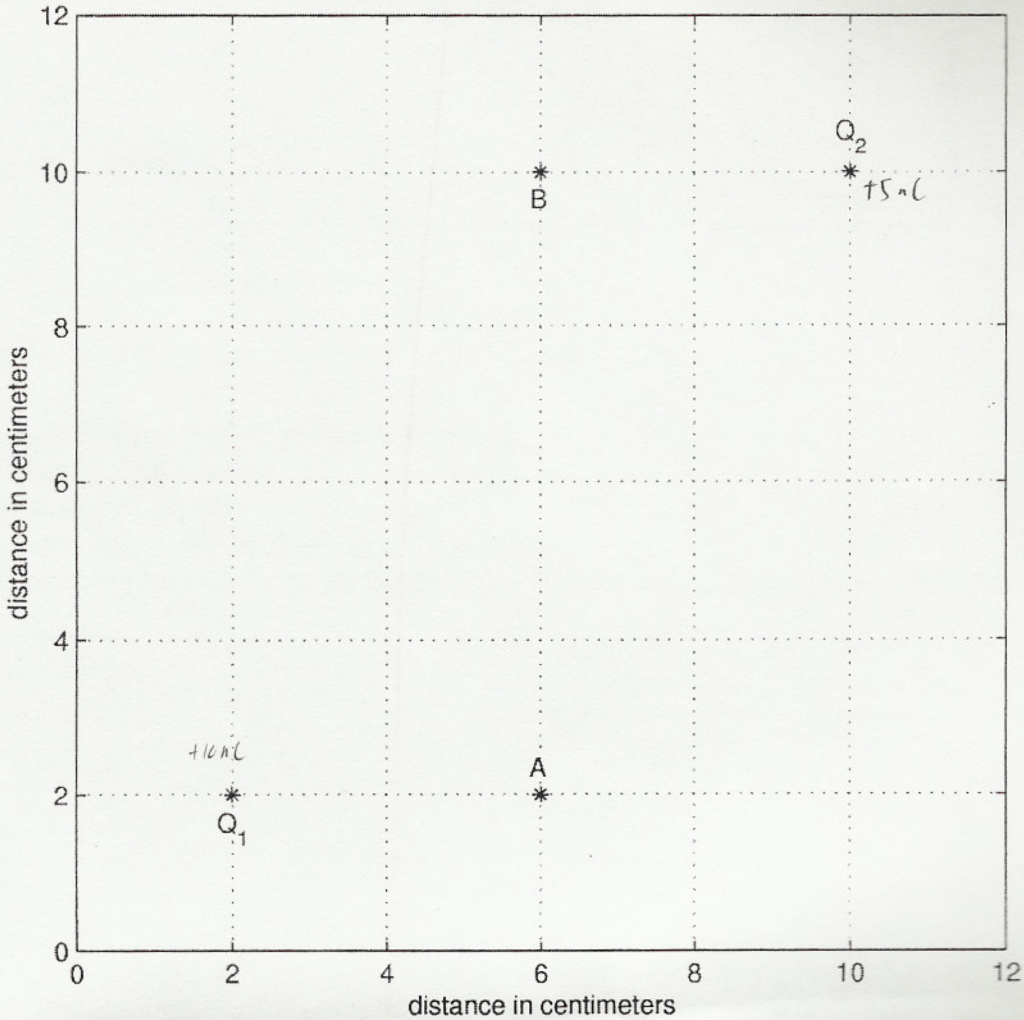
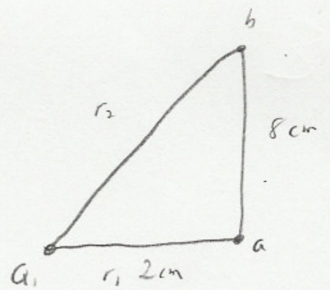
Problem 1. Figure 1 shows the location of two positively charged particles, Q_1 and Q_2. The particle denoted Q_1 has a positive charge of 10 nC and the particle denoted Q_2 has a positive charge of 5 nC. The two particles have (x,y) coordinates (2,2) and (10,10) respectively, where each coordinate has units centimeters.

a) How much work is required to move a test charge of 2 mC from point A to point B [point A has coordinates (6,2) and point B has coordinates (6,10)]? **(3 marks)**

b) What is V_{BA}? **(3 marks)**





A) $w_1 = k\ Q_1\ Q_t \left|\frac{r_2 - r_1}{r_2\ r_1}\right|$

$w_1 = (9.0\times10^9)(10\times10^{-6})(2\times10^{-3})\left|\frac{0.0824-0.02}{0.165}\right|$

0

$w_1 = 68.1$ J

$r_2 = \sqrt{2^2+8^2}$

$r_2 = 8.24$ cm

$r_2 = 0.0824$ m

No time left

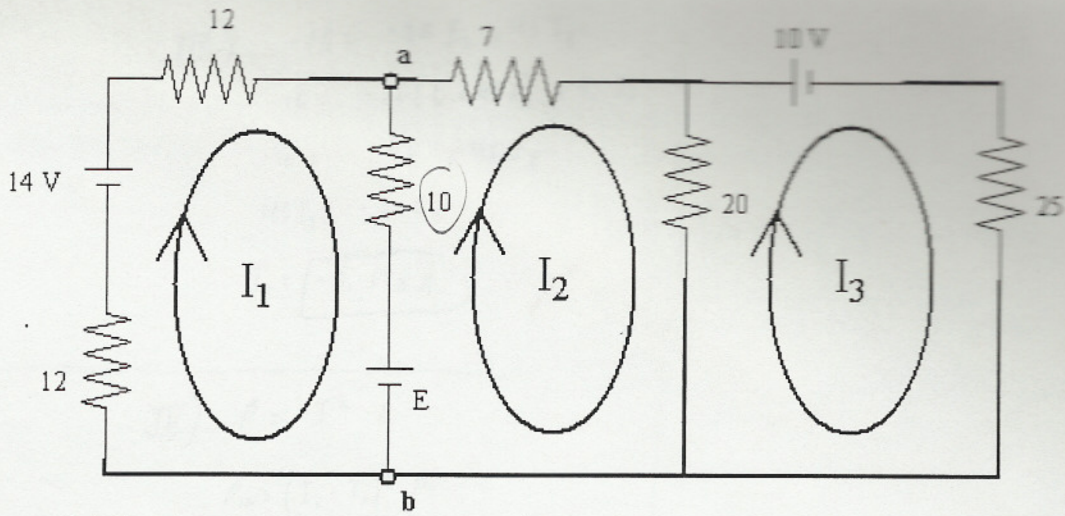


Figure 2 (all resistances are in Ohms)

Given $\mathbf{I_1 = 0.323}$ **A** and $\mathbf{I_2 = 0.099}$ **A** :

i) What is the voltage across the **10 Ω** resistor? **(3 marks)**
ii) What is the voltage $\mathbf{V_{ab}}$? **(3 marks)**
iii) What is the current $\mathbf{I_3}$? **(3 marks)**
iv) What is power dissipated in the **10 Ω** resistor? **(3 marks)**
v) Write the loop equations for the circuit shown in Figure 2. Use the matrix template given below. **(3 marks)**

$V_{10\Omega} =$ 2.24 V 3	$I_3 =$ -0.178 A 3
$V_{ab} =$ 9.48 V ✗	$Power_{10\Omega} =$ 0.502 W 3
Equations	

$$\begin{pmatrix} 24 & -10 & 0 \\ -10 & 17 & -20 \\ 0 & -20 & 45 \end{pmatrix}\begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 6.762 \\ 7.238 \\ -10 \end{pmatrix}$$ ✗ 9

$14V - E = I_1(12+12) - I_2(10)$

① $14 - E = 24I_1 - 10I_2$

$E = I_2(10+7) - I_1(10) - I_3(20)$

$E = 17I_2 - 10I_1 - 20I_3$

② $E = -10I_1 + 17I_2 - 20I_3$

$-10V = I_3(20+25) - I_2(20)$

$-10 = 45I_3 - 20I_2$

$-10 = -20I_2 + 45I_3$

$14 - E = 24I_1 - 10I_2$

$14 - E = 24(0.323) - 10(0.099)$

$14 - E = 7.752 - 0.99$

$-E = -7.238$

$E = 7.238$ V

$14 - E =$

$14 - 7.238 =$

6.762 V

I) $V_{10\Omega} = I_T R$

$V_{10\Omega} = (I_1 - I_2) R$

$V_{10\Omega} = (0.323 - 0.099)(10)$

$V_{10\Omega} = \boxed{2.24 \text{ V}}$

II) $V_{ab} = V_c + V_0$

$V_{ab} = E + I R_{10}$

$V_{ab} = (7.238 V) + (I_1 - I_2) R_{10}$

$V_{ab} = (7.238 V) + 2.24 V$

$V_{ab} = 9.478$ V

$V_{ab} = \boxed{9.48 \text{ V}}$ ✗

a) Write the nodal equations for the circuit shown in Figure 3. Use the matrix template given below. **(3 marks)**

b) Solve for the voltages V_1 and V_2. **(3 marks)**

c) Find the magnitude and direction of the current through the 3-Ω resistor. **(3 marks)**

d) Find the magnitude and direction of the current through the 6-Ω resistor. **(3 marks)**

V_1= 0.728 V	$I_{3\Omega}$= 0.477 A	Direction of $I_{3\Omega}$ Circle the correct answer Left Right
V_2= 1.28 V	$I_{6\Omega}$= 0.0920 A	Direction of $I_{6\Omega}$ Circle the correct answer Left Right

Conflict here!

3

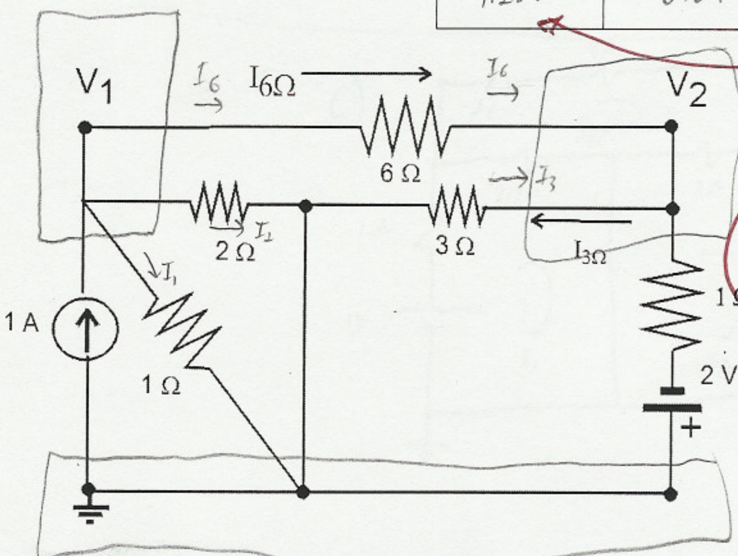
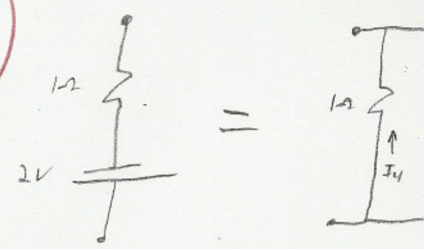


Figure 3.

ref



$I = \frac{V}{R} = \frac{2V}{1\Omega} = 2A.$

$$\begin{pmatrix} 5/3 & -1/6 \\ -1/6 & 3/2 \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix} = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$$

2

A) $I_{in} = I_{out}$

$1A = I_1 + I_2 + I_6$

$1 = \frac{V_1}{1} + \frac{V_1}{2} + \frac{V_{12}}{6}$

$1 = V_1 + \frac{1}{2}V_1 + \frac{1}{6}V_1 - \frac{1}{6}V_2$

$1 = V_1(1 + \frac{1}{2} + \frac{1}{6}) - V_2(\frac{1}{6})$

$1 = \frac{10}{6}V_1 - \frac{1}{6}V_2$

$1 = \frac{5}{3}V_1 - \frac{1}{6}V_2$

$I_{out} = I_{in}$

$2A = I_4 + I_3 + I_6$

$2 = \frac{V_2}{1} + \frac{V_2}{3} + \frac{V_{21}}{6}$

$2 = V_2 + \frac{1}{3}V_2 + \frac{1}{6}V_2 - \frac{1}{6}V_1$

$2 = V_2(1 + \frac{1}{3} + \frac{1}{6}) - V_1(\frac{1}{6})$

$2 = \frac{3}{2}V_2 - \frac{1}{6}V_1$

Algebra and error a

B) $1 = \frac{5}{3}V_1 - \frac{1}{6}V_2$

$2 = \frac{3}{2}V_2 - \frac{1}{6}(\frac{3}{5} + \frac{1}{10}V_2)$

$V_1 = \frac{3}{5} + \frac{1}{10}(1.28)$

$V_1 = \boxed{0.728\ V}$

Problem 4. Using superposition (Figure 4), find

a) the current through the 2-Ω resistor due to the voltage source. **(3 marks)**
b) the current through the 2-Ω resistor due to the current source. **(3 marks)**
c) the power dissipated by the 2-Ω resistor. **(3 marks)**

$I_{2\Omega}$(volt.source) = 0.3 A	$I_{2\Omega}$(curr.source) = 0.958 A	$P_{2\Omega}$ = 3.17 W

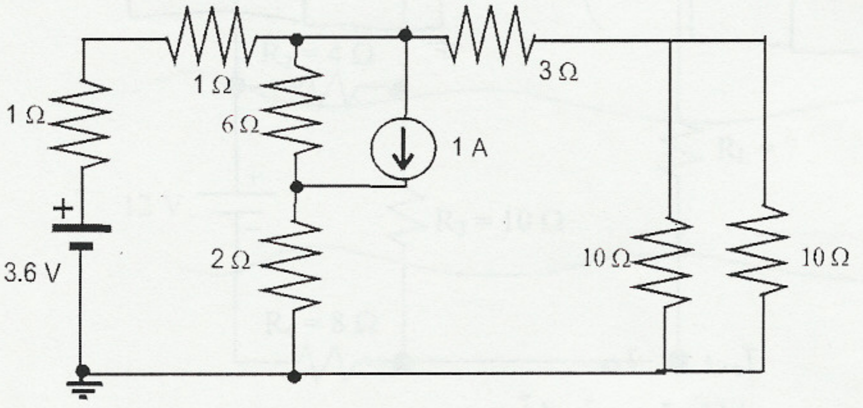
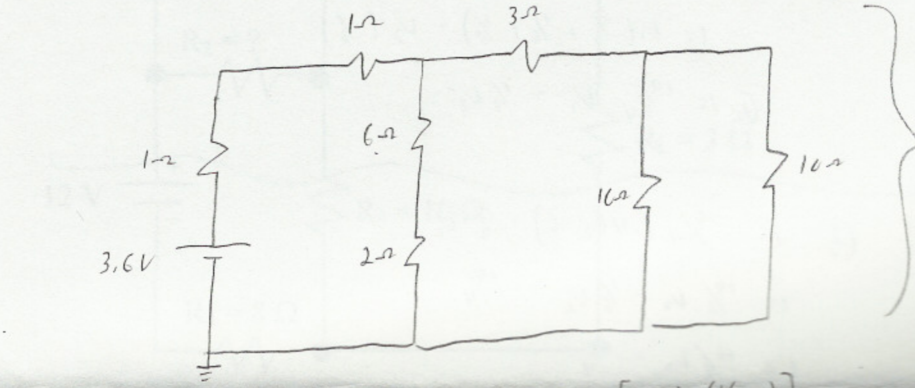
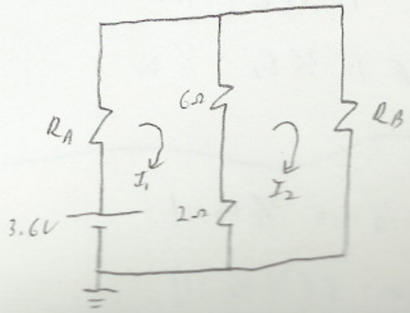


Figure 4.

Voltage Source





$R_A = (1\Omega) + (1\Omega)$

$R_A = 2\Omega$

$R_B = (3\Omega) + [(10\Omega) // (10\Omega)]$

$R_B = (3\Omega) + (5\Omega)$

$R_B = 8\Omega$

$3.6V = I_1(2+6+2) - I_2(2+6)$

① $3.6 = 10 I_1 - 8 I_2$

$0 = I_2(8+6+2) - I_1(6+2)$

② $0 = 16 I_2 - 8 I_1$

① $10 I_1 = 3.6 + 8 I_2$

$I_1 = 0.36 + 0.8 I_2$

② $0 = 16 I_2 - 8(0.36 + 0.8 I_2)$

$0 = 16 I_2 - 2.88 - 6.4 I_2$

$2.88 = 9.6 I_2$

$I_2 = 0.3 A$

① $I_1 = 0.36 + 0.8 I_2$

$I_1 = 0.36 + 0.8(0.3)$

$I_1 = 0.36 + 0.24$

$I_1 = 0.6 A$

3

$I_{2\Omega} = I_1 - I_2$

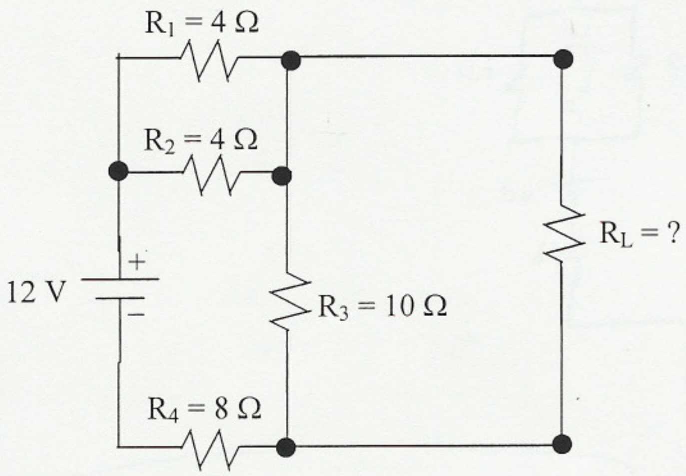
Problem 5. In the circuits shown below, the objective is to achieve maximum power dissipation by the load resistor R_L in ***each*** case.

Part a	Part b
$R_L =$ 5 Ω	$R_2 =$ −2.35 Ω

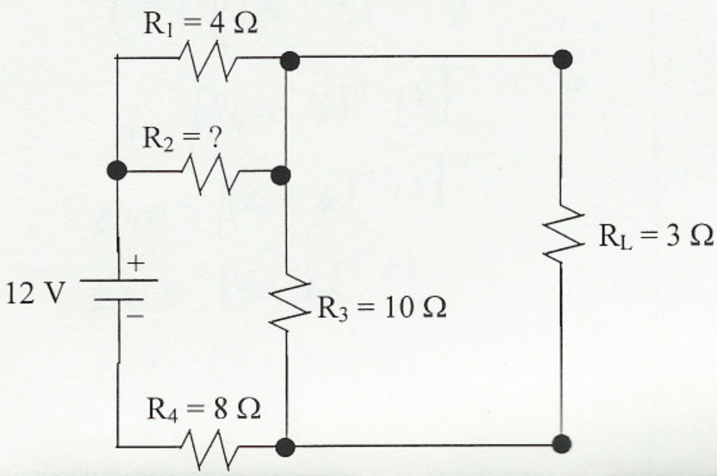
5

What does it mean?

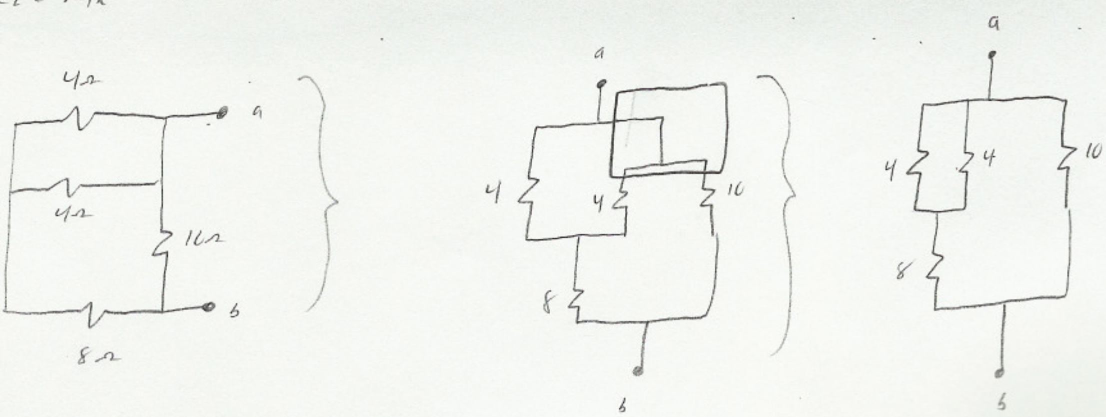
(a) What is the value of R_L for maximum power dissipation by R_L? **(3 marks)**



(b) What is the value of R_2 if there is maximum power dissipation by R_L (3Ω)? **(3 marks)**



A) $R_L = R_{Th}$ for max power



$R_{Th} = \left[\left[(4\Omega)//(4\Omega)\right] + (8\Omega)\right] // (10\Omega)$

$R_{Th} = \left[(2\Omega) + (8\Omega)\right] // (10\Omega)$

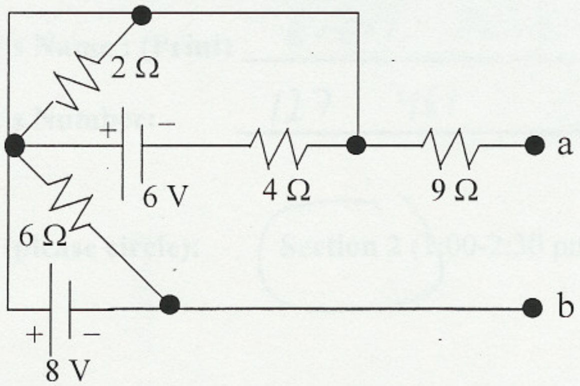
Problem 6.

i. Determine the Thévenin equivalent circuit between terminals "a" and "b" for the circuit shown below, *i.e.* what is R_{Th} and E_{Th}? **(6 marks)**

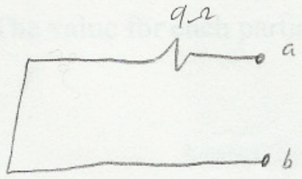
ii. Draw the Thévenin equivalent circuit, you are to clearly indicate the polarity of the battery and the terminals "a" and "b". **(3 marks)**

R_{Th} = 9Ω	E_{Th} = 8V
Thévenin circuit	

9

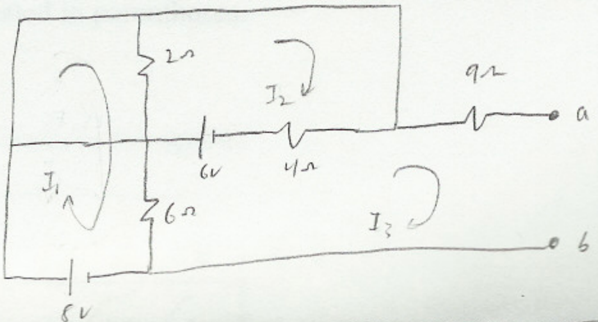


R_{Th}



$R_{Th} = 9Ω$

$E_{Th} = 8V$



$8V = I_1(2+6) - I_2(2)$

① $8 = 8I_1 - 2I_2$

② $I_3 = 0$

$6V = I_2(2+6) - I_1(2)$

③ $6 = 8I_2 - 2I_1$

① $8 = 8I_1 - 2I_2$

$8I_1 = 8 - 2I_2$

$I_1 = 1 - \frac{1}{4}I_2$

③ $6 = 8I_2 - 2(1 - \frac{1}{4}I_2)$

$6 = 8I_2 - 2 + \frac{1}{2}I_2)$

$8 = \frac{15}{2}I_2$

$I_2 = \frac{16}{15}$

$E_{Th} = V_{ab} = \boxed{8V}$